Application of Low Molecular Weight Dextran for Improved Security Filtration

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Abstract

Low molecular weight dextran can be used to improve liquor stability during security filtration. The precipitation of alumina prior to (and during) filtration restricts the level of liquor supersaturation targeted in digestion, impacting the efficiency of production of alumina tri-hydrate. The addition of ppm levels of Alclar® 5000, a low molecular weight dextran, to the filter feed slurry may facilitate increased liquor productivity, a reduction in filtration scaling events, reduced flow losses in filtration and reduced maintenance costs and process upsets. This paper presents an overview of the implementation of Alclar® 5000 at Alcoa's Wagerup refinery in Western Australia using several liquor characteristics and Alcoa's stability model to demonstrate the efficacy of Alclar® 5000.

Keywords: Security filtration, dextran, Bayer liquor productivity.

1. Introduction

The unwanted precipitation of alumina tri-hydrate during security filtration is known as autoprecipitation. Kelly type filters and sand filters are prone to autoprecipitation which causes filter cloth blinding and cementation of the sand bed resulting in flow losses, filtration scaling events, reduced liquor productivity and increased operating costs.

Security filtration of red mud thickener overflow aims to limit the solids in the filtrate to ensure that targeted product quality is achieved [1]. There are many strategies available to overcome the challenges associated with security filtration; refineries may increase the frequency of maintenance, increase the amount of equipment sparing, increase availability of operations support, but most significantly refineries operate with conservative supersaturation conditions. These strategies lead to inefficient processing conditions and adherence to an operational window for liquor supersaturation that is less than optimal, which increase costs and decrease productivity.

Dextran has a long history of use in the Bayer process, as a flocculant and a filter aid and is often used in combination with other reagents to increase settling rate and underflow density, to reduce overflow solids, improve security filtration and scale control.

Patent WO 2012/031316 A1 [2] describes the addition of ppm levels of a low molecular weight dextran, to security filtration feed slurry increases the stability of liquor with respect to alumina tri-hydrate precipitation during filtration, without affecting the controlled precipitation of alumina tri-hydrate during downstream processing. Increased liquor stability during filtration allows the upper limit of the operational window for supersaturation to be increased without affecting filter availability.

This paper outlines the findings of laboratory test work, a pilot plant application and a refinery trial of Alclar® 5000, a low molecular weight dextran, at Alcoa's Wagerup refinery in Western Australia.

2. Experimental

2.1 Laboratory Methods

A matrix of laboratory stability tests was conducted where the hot pregnant liquors propensity to autoprecipitate was measured by the change in A/TC ratio. Dose response tests were conducted using thickener overflow liquor collected from the D-tanks (surge tanks prior to filtration). The liquor was dosed with the desired ppm level of Alclar® 5000, then transferred to either a 3 L stirred reactor or divided into 250 mL bottles and placed in a rotating water bath, along with un-dosed control samples, at temperatures ranging between 95 °C and 103 °C (salt was added to achieve higher temperatures).

Samples were taken from each bottle/reactor at regular time intervals and analysed by titration for alumina and caustic (A/TC ratio). Replicate bottles were required to avoid errors due to excessive sampling.

The efficacy of Alclar® 5000 at a particular set of conditions was determined by monitoring the difference between the A/TC ratio at the start compared with the A/TC ratio at each sample time.

2.2 Pilot Trial

Pilot plant trials were completed under controlled conditions at Alcoa's Wagerup refinery in Western Australia. Two, almost identical 'Kelly filtration' pilot rigs that are 1/100th of the scale of full operating vessels were run with and without the addition of Alclar® 5000. The pilot plants are plumbed directly into refinery process streams including liquor and filter aid and are able to have modified liquor and operating conditions.

Liquor from the thickener overflow tanks was piped to the feed tank on each rig, this liquor did not have filter aid dispersed into it. A separate filter aid line was provided to each rig so that the filter aid dose could be strictly controlled. Lakewater and caustic wash solution from the plant were also available to the rigs. A schematic of the Kelly filtration pilot rigs is shown in Figure 1.

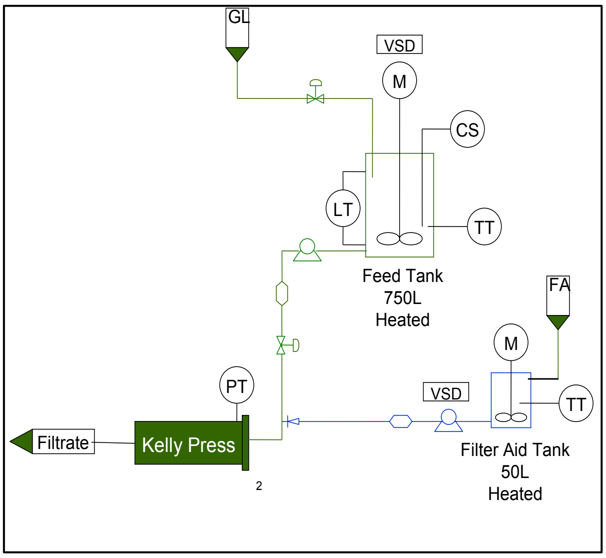

Figure 1. Schematic of the Kelly filtration pilot rig. TT = Temperature Transmitter, CS = Chemical Sparge, LT = Level Transmitter, GL = Green Liquor, PT = Pressure Transmitter, FA = Filter Aid.

Pilot rig conditions replicated refinery operating targets, e.g. filter aid:mud ratio, flow, pressure etc. The change in pressure measured at the Kelly press is a proxy for change in cake resistance and an indication of precipitation of alumina tri-hydrate occurring within the filter cake.

Without autoprecipitation the filtration pressure should build linearly under normal conditions with the addition of filter cake over the filter cycle time. However, should autoprecipitation occur, the cake blinds and rapidly increases filtration resistance which is seen in as a rapid increase of pressure.

3. Results and Discussion

An investigation of the efficacy of Alclar® 5000 to supress the precipitation of alumina tri-hydrate has been conducted focusing on dose response at a given set of liquor conditions. Figure 2 shows that as low as 5 ppm is sufficient to inhibit the onset of precipitation in a filter cake at time frames equivalent to filtration cycle times. The onset of precipitation is represented by decreasing A/TC ratio, however this is not the only indicator of liquor stability. Alcoa's Technology Delivery Group (TDG) has developed a model that considers the variables and performance indicators associated with security filtration other than A/TC ratio such as filter cake resistance. The outcome is a unitless 'stability measure' which defines a liquors propensity to precipitate. Figure 3 demonstrates a linear response rate to increasing stability with dose rate of the product. The numerical value assigned as the 'stability measure' is calculated using a combination of laboratory test results that are weighted according to their impact on liquor stability. Figure 4 shows that under pilot filtration conditions which replicate refinery operations that the addition of 10 ppm of Alclar® 5000 prevents the onset of precipitation which can be seen to occur after approximately three hours in the pilot rig without the addition of Alclar® 5000.

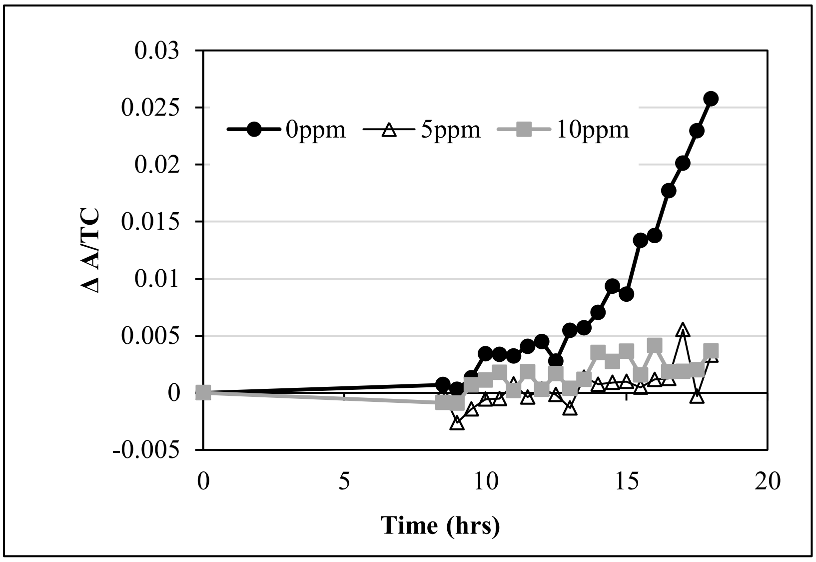

Figure 2. Stability of D-tank liquor over time at various Alclar® 5000 dose rates.

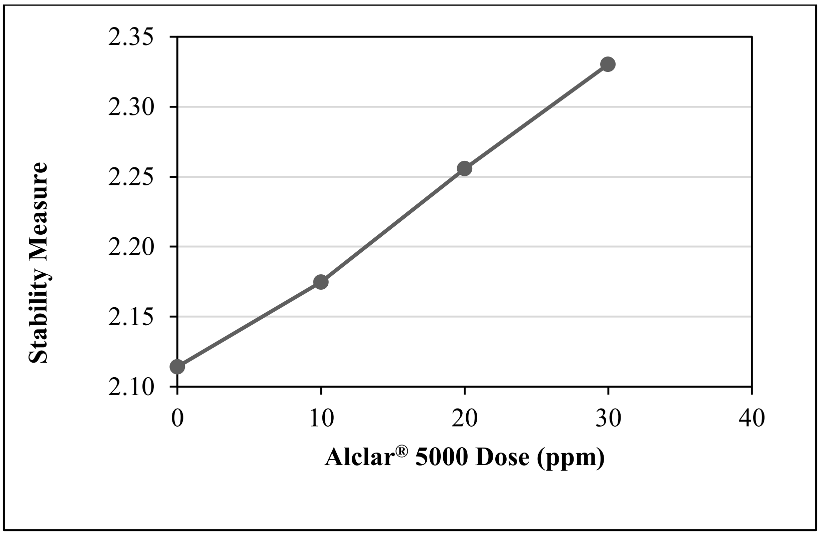

Figure 3. Dose response of Wagerup liquor stability with increasing levels of Alclar® 5000.

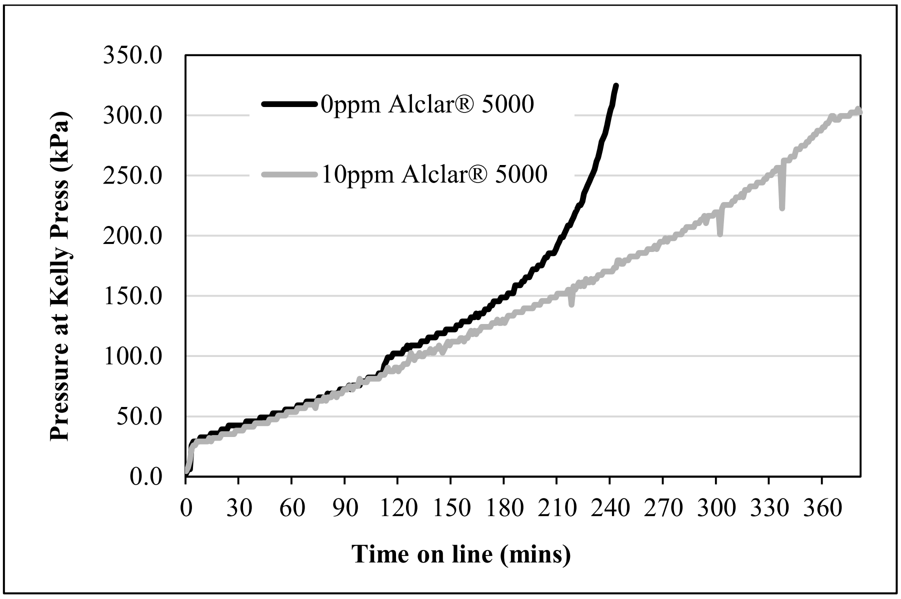

Figure 4. Pressure measured at the pilot rig Kelly Press for D-tank liquor with and without Alclar® 5000.

An important consideration when applying Alclar® 5000 is the dilution liquor. Normally refineries prefer to dilute with high alumina and caustic liquor to avoid increased dilution. However, low caustic concentration dilution liquor is the most effective and therefore the positive impact of Alclar® 5000 needs to be offset against the negative impact of dilution.

Given the success of the laboratory tests and the pilot trials, Alcoa were prepared to trial Alclar® 5000 in the full-scale refinery environment. The plant trial data shown in Figure 5 indicates that the filters used in the refinery trial were run until autoprecipitation was observed by an increase in filtration resistance. Alcoa's stability model, which is Alcoa's proprietary technology, was used to predict the time to autoprecipitation with and without Alclar® 5000 and the actual time taken was measured during the trial. The trial data was collected on three separate occasions hence the model predicted baseline without the addition of Alclar® 5000 are slightly different on each occasion. This is due to slight differences in liquor properties on each occasion hence the predicted time to autoprecipitate is not constant but is reflective of the conditions in the refinery at the time.

The stability model predicts that when Alclar® 5000 is added at 5 and 8 ppm there is a significant increase in the time taken for autoprecipitation to occur, demonstrating the stability benefit. The measured values are almost identical to the model predictions.

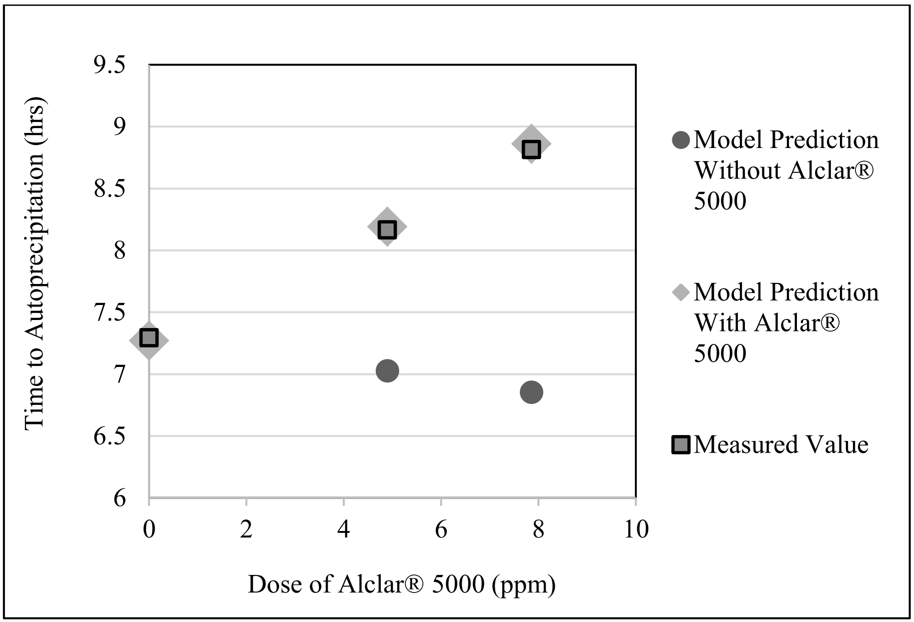

Figure 5. Plant trial of Alclar® 5000 at Alcoa's Wagerup refinery in Western Australia.

The process benefits resulting from the application of Alclar® 5000 include increased liquor productivity via reduced flow interruptions from filter cake scale or via increasing A/TC ratio in digestion. Additionally, reduced maintenance costs and reduced process upsets and troubleshooting associated with process upsets are realized.

4. Conclusion

Depending on refinery design and operating conditions, Alclar® 5000 can be used to improve liquor stability in the D-tanks prior to security filtration. Increased liquor stability allows one or more of the following process and cost benefits to be realised:

1. Increase liquor productivity
2. Reduce flow losses in filtration
3. Reduce filtration scaling events
4. Reduce maintenance and costs related to process upsets

5. References

1. R Bott, T Langeloh and J Hahn, Advanced Filtration Methods for Pregnant Liquor Purification, *Light Metals 2008*, 444-448.
2. G. A. Hanna, M. Loan and F. A. Lee, Method of Increasing the Stability of a Bayer Process Liquor, (2012) Patent WO 2012/031316 A1.